AUSTRALIAN RESUSCITATION COUNCIL

ARC Guideline 11.1 – Introduction to and Principles of In-hospital Resuscitation

Summary

This guideline focuses on in-hospital resuscitation and provides background information on BLS and ALS appropriate for the in-hospital environment. It should be read in conjunction with BLS, ALS and Paediatric guidelines.

Who does this guideline apply to?

This guideline applies to adults and children who require advanced life support (ALS) in an in-hospital environment.

Who is the audience for this guideline?

This guideline is for health care professionals in hospital environments where equipment and medications are available.

Recommendations

The Australian Resuscitation Council (ARC) recommends that:

1. As soon as possible, Advanced Life Support treatments are used to supplement the care of any patient receiving Basic Life Support.
2. Hospitals use early warning, rapid response team, or medical emergency team systems to reduce the incidence of in-hospital cardiac arrests, and in-hospital mortality, and to treat patient deterioration.
3. Hospitals use a system validated for their specific patient population to identify individuals at increased risk of serious clinical deterioration, cardiac arrest, or death, both on admission to hospital and during their stay.

Systems should ensure:

- clinical deterioration is recognised early to prevent cardiac arrest;
- cardiorespiratory arrest is recognised immediately;
- help is summoned using a specific telephone number/call system;
- CPR is started immediately and, if indicated, defibrillation is attempted as soon as possible (ideally within 3 min).

Guideline

1 Guideline Process

This guideline updates Guideline 11.1, incorporates the previous Guideline 11.1.1 Cardiopulmonary Resuscitation for Advanced Life Support Providers, and includes new material related to in-hospital resuscitation partly based on the Resuscitation Council (UK) In-hospital resuscitation document.[1] This guideline includes evidence from the 2015 ILCOR review process using GRADE methodology and the NHMRC methodology used in the previous Guideline 11.1.1. The guideline process includes involvement of stakeholders from all member organisations of the ARC, and peer review by the Australian Resuscitation Council and their Executive Committee. Details of the guidelines development process can be found on the ARC website https://resus.org.au

2 Summary of changes

Combines previous Guidelines 11.1 and 11.1.1 with the addition of further information on principles of in-hospital resuscitation.

3 Introduction

This guideline is aimed primarily at health care professionals who are likely to be the first to respond to an in-hospital cardiac arrest or significant clinical deterioration. It may also be applicable to healthcare professionals working in other clinical settings. The ARC document Standards for Resuscitation: Clinical Practice and Education supports the implementation of this guideline. https://resus.org.au/standards-for-resuscitation-clinical-practice-and-education

Except where specified, the advice is the same for infants (other than newborns) and children as it is for adults.

4 Prevention of Cardiac Arrest

Children and young adults presenting with characteristic symptoms of arrhythmic syncope should have a specialist cardiology assessment, which should include an ECG and in most cases an echocardiogram and exercise test.[2] [Class A, Expert consensus opinion]

Characteristics of arrhythmic syncope include: syncope in the supine position, occurring during or after exercise, with no or only brief prodromal symptoms, repetitive episodes, or in individuals with a family history of sudden cardiac death (SCD). In addition, non-pleuritic chest pain, palpitations associated with syncope, seizures (when resistant to treatment, or occurring at night) should raise suspicion of increased risk of arrhythmic syncope. Systematic evaluation in a clinic specialising in the care of those at risk for SCD is recommended in family members of young victims of SCD or those with a known cardiac disorder resulting in an increased risk of SCD.[2] [Class B; Expert consensus opinion]

5 In-Hospital Pre-Arrest Detection and Management

In adult patients admitted to hospital, there is variable evidence regarding the use of early warning systems/rapid response team (RRT) systems or medical emergency team (MET) systems (compared with no such systems) to reduce cardiac and respiratory arrests and hospital mortality.[2]

ARC suggests that hospitals consider the introduction of an early warning score EWS/response team/MET system to reduce the incidence of in-hospital cardiac arrests (IHCA) and in-hospital mortality (CoSTR 2015 weak recommendation, low-quality evidence).[3] It is reasonable, and increasingly mandated by health authorities, that hospitals provide a system of care that includes[2,4] :

- staff education about the signs of patient deterioration;
- appropriate and regular vital signs monitoring of patients;
- clear guidance (e.g. via calling criteria or early warning scores) to assist staff in the early detection of patient deterioration;
- a clear, uniform system of calling for assistance, and;
- a clinical response to calls for assistance.

[Class A; Expert consensus opinion]

There is insufficient evidence to identify the best methods for the delivery of these components, and on current evidence, this should be based on local circumstances.[2, 4] [Class A; Expert consensus opinion] Hospitals should use a system validated for their specific patient population to identify individuals at increased risk of serious clinical deterioration, cardiac arrest, or death, both on admission and during hospital stay.[2] [Class A; Expert consensus opinion].

There is insufficient evidence to identify specific educational strategies that improve outcomes (e.g. early recognition and rescue of deteriorating patient at risk of cardiac/respiratory arrest). Educational efforts have a positive impact on knowledge, skills, attitudes and confidence, and increase the frequency of activation of a response and should therefore be considered.[2] [Class A; Expert consensus opinion].

6 The importance of BLS

BLS is only a temporary measure to maintain ventilation and circulation. Effective chest compression provides a cardiac output of only 20-30% of the pre-arrest value [5], and rescue breathing without supplemental oxygen provides ventilation with an inspired oxygen concentration of only 15%.[2,6] Electrical defibrillation is the mainstay of treatment for ventricular fibrillation and pulseless VT. The chance of successful defibrillation decreases with time. Therefore high quality CPR and decreasing the time to defibrillation are the first priorities in resuscitation from cardiac arrest. The purpose of BLS is to help maintain myocardial and cerebral oxygenation until ALS personnel and equipment are available:

- effective BLS may increase the likelihood of successful defibrillation.[7]
- effective BLS buys time until reversible causes can be diagnosed and/or treated.

Monitoring CPR quality and resuscitation performance is an important element of Basic and Advanced Life Support and includes:

- effectiveness of compressions (adequacy of depth, rate and minimising hands off periods);
- adequacy of ventilation (avoiding over-ventilation and consequent deleterious effects);
- timing of defibrillation with regard to likelihood of success (as soon as possible and providing compressions before and after).

Patient care during the pre-arrest period (early detection and prevention of cardiac arrest) and the post-resuscitation management are also vital to improving patient outcomes.

An extensive review of many aspects of advanced life support was performed as part of the 2010 and 2015 Consensus on Science process.[8-14] The information from this process has been incorporated into the guidelines wherever appropriate.

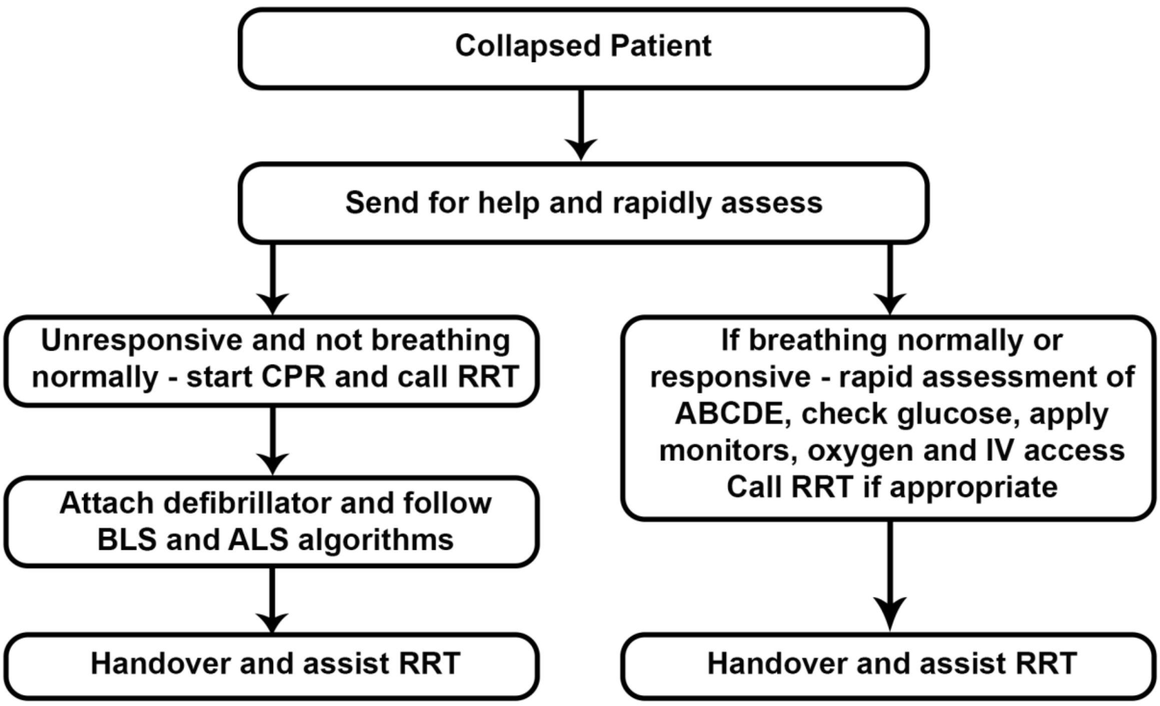
After in-hospital cardiac arrest the division between Basic Life Support (BLS) and Advanced Life Support (ALS) is arbitrary; in practice, the resuscitation process is a continuum but BLS and ALS are specifically defined in the ARC Glossary. For all in-hospital cardiac arrests, ensure:

- cardiorespiratory arrest is recognised immediately;
- help is summoned using a specific telephone number/call system;
- CPR is started immediately and, if indicated, defibrillation is attempted as soon as possible (ideally within 3 min).

All in-hospital cardiac arrests should be reviewed as part of an audit and quality improvement process. Details should be recorded after each event.

7 Sequence for a patient in need of resuscitation in hospital

Actions for health care professionals attending a collapsed patient in need of resuscitation in hospital are summarised in the following algorithm: Figure 1.



RRT: Rapid Response Team

7.1 Personal safety and protective equipment

The personal safety of all individuals involved in resuscitation is paramount. While there are very few reports of harm to rescuers during resuscitation the following principles should apply:

- always check that the environment and patient surroundings are safe before proceeding.
- put on personal protective equipment (PPE) as soon as possible and as appropriate to the patient's clinical status. Local infection control policies should be followed.
- all sharps should be handled with care and disposed of in a sharps container which should be immediately available. Staff are responsible for the safe disposal of sharps they have used.
- safe manual handling techniques according to local policies should be used when moving patients during resuscitation, to protect both patients and staff.
- staff are clear of patient while shocks are delivered or the defibrillator is disarmed, prior to recommencement of chest compressions.

7.2 Checking the patient for a response

Following a witnessed collapse or finding a collapsed patient, assess for response (ANZCOR Guideline 3). If other members of staff are nearby it will be possible to undertake several actions simultaneously.

7.3 If the patient responds

The patient will still require urgent medical assessment, so send for help according to local protocols. This usually involves calling a Rapid Response Team (e.g. Medical Emergency Team (MET)).

Rapidly assess the patient using the Airway, Breathing, Circulation, Disability, Exposure (ABCDE) approach including check blood glucose level, applying monitors (pulse oximeter, ECG, blood pressure), giving oxygen if indicated and obtaining IV or intraosseous (IO) access. Use the pulse oximeter to guide oxygen therapy (see Guideline 11.6.1 Targeted oxygen therapy in adult advanced life support). Record vital signs and other assessments, addressing abnormalities according to the abilities of those responding, and prepare to handover to the Rapid Response Team using the ISBAR (Identify, Situation, Background, Assessment, Recommendation) framework.

7.4 If the patient does not respond

Send for help as assistance will be needed immediately, and assess response, airway and breathing according to ANZCOR BLS Flowchart (ANZCOR Guideline 8) then follow the ANZCOR Advanced Life Support Guideline 11.2.

Turn the patient onto their back and open the airway using head tilt, chin lift or jaw thrust manoeuvres. If there is a risk of cervical spine injury, jaw thrust or chin lift is preferred to head tilt but a patent airway, oxygenation and ventilation takes priority over concerns about potential cervical spine injury.

Keeping the airway open, look, listen, and feel to determine if the patient is breathing normally. This should take less than 10 seconds and involves:

Looking for chest movement (breathing or coughing)

Listening at the patient's mouth for breath sounds

Feeling air movement on your hand/cheek

Looking for other movement or signs of life

If the adult patient is not responsive and not breathing normally, commence chest compressions (see ANZCOR Guideline 6). For children, CPR by advanced life support providers should commence with 2 ventilations before starting chest compressions (see ANZCOR Guideline 12.2). If trained and experienced in assessment of circulation in collapsed patients: check for breathing and a central pulse at the same time. If there is any question over the presence or absence of a pulse it must be treated as if it were absent. Delays in diagnosing cardiac arrest and starting CPR will adversely affect chances of survival and must be avoided, so if there is any doubt, commence CPR. Chest compressions in a patient who is collapsed, unresponsive and not breathing normally, and whose heart is still beating are unlikely to cause harm.

Agonal breaths (occasional, irregular gasps) are common in the early stages of cardiac arrest and are a sign of cardiac arrest. Agonal breathing and limb movement can also occur during effective chest compressions as cerebral perfusion improves, but are not indicative of a return of spontaneous circulation (ROSC).

Changes in skin colour (e.g. pallor, cyanosis) in isolation are not diagnostic of cardiac arrest.

Get resuscitation equipment and attach a defibrillator. If you are alone, you will need to leave the patient temporarily to get equipment. If the patient is already attached to monitoring in a critical care area this will facilitate rapid assessment but does not negate the need for clinical assessment.

Commence 30 chest compressions followed by 2 ventilations, and continue with a ratio of 30:2. For children, after initial 2 ventilations, continue with 15 chest compressions followed by 2 ventilations (a ratio of 15:2).

The hand position for chest compression is the middle of the lower half of the sternum. This hand position can be found quickly by teaching placement of the heel of one hand in the centre of the chest with the other hand on top, and demonstrating placing hands in the middle of the lower half of the sternum. In smaller children, one hand may be sufficient to provide adequate compression depth. A two-thumb technique is preferred for delivering compressions to an infant.

Ensure high quality chest compressions:

- depth of >5 cm (adult). In children, compression depth should be approximately 1/3 the antero-posterior (AP) diameter of the chest (4cm in infants, 5cm in children).
- rate of 100–120 compressions min

- allow the chest to recoil completely after each compression
- take approximately the same amount of time for compression and relaxation
- minimise any interruptions to chest compression (hands-off time)

After ventilations, resume compressions without delay.

Equipment should be immediately available in clinical areas to manage the airway and assist with ventilation (e.g. a Pocket resuscitation mask, self-inflating bag-mask, or a supraglottic airway device and bag).

There may be reasons to avoid mouth-to-mouth ventilation in the clinical setting, but there may be situations where giving mouth-to-mouth ventilation could be lifesaving (e.g. when there is a delay in resuscitation equipment arriving or in non-clinical settings). If there are good clinical reasons to avoid mouth-to-mouth, or if the responder is unable to do it, they should concentrate on performing continuous chest compressions until more experienced help or airway equipment arrives.

Use an inspiratory time of about 1 second and give enough volume to cause the chest to visibly rise.

Avoid rapid or forceful breaths, and add supplemental oxygen as soon as possible.

Supraglottic airway placement and tracheal intubation should be attempted only by those who are trained, competent and experienced in the skill. Attempts to secure an airway should occur with minimal interruptions (less than 5 seconds) to chest compressions.

Quantitative capnography (ideally waveform) must be used routinely to confirm tracheal tube placement, and should also be used with a supraglottic airway, and continued during CPR. Waveform capnography also allows assessment of the quality of CPR, provides an indication of ROSC and helps determining prognosis during CPR (ANZCOR Guideline 11.6).

After an advanced airway (supraglottic airway/tracheal tube) is placed during CPR, it is reasonable to ventilate the lungs at a rate of 6 to 10 ventilations per minute without pausing during chest compressions to deliver ventilations (ANZCOR Guideline 11.6).

As soon as an automated external defibrillator (AED) arrives, follow the prompts that will guide use.

For a manual defibrillator apply the self-adhesive pads to the patient's chest whilst chest compressions continue, and charge the defibrillator. The adhesive electrode pads will enable a more rapid assessment of cardiac rhythm, compared with attaching ECG electrodes.

When the defibrillator is charged pause briefly to check cardiac rhythm. Chest compression pause should be < 5 seconds.

If the rhythm is ventricular fibrillation/pulseless ventricular tachycardia (VF/pVT) deliver the shock and restart chest compressions immediately. Do not delay restarting chest compressions to check the cardiac rhythm.

If asystole is seen, disarm defibrillator or dump the charge into machine (following the manufacturers' instructions) then continue CPR and follow the non-shockable algorithm.

If a potentially stable rhythm is seen, dump the charge and check for a pulse before considering restarting chest compressions.

The interval between stopping compressions and delivering a shock must be minimised.

Longer interruptions to chest compressions reduce the chance of a shock restoring a spontaneous circulation.

Team actions should be planned before pausing chest compressions.

Initial responder resuscitation should continue until the resuscitation team arrives or the patient responds or starts to breathe normally, and follow the ALS algorithm (Guideline 11.2).

Identify the person to be responsible for handover to the resuscitation team leader, and use structured communication for handover (e.g. ISBAR).

7.7 If the patient is not breathing and has a pulse (respiratory arrest)

Ventilate the patient's lungs (as described above, 6-10 inflations per minute) and check for a pulse every 10 breaths (about every minute).

If there is doubt about the presence of a pulse, start chest compressions and continue ventilations until more experienced help arrives. All patients in respiratory arrest will develop cardiac arrest if ventilation is delayed.

7.8 If the patient has a monitored and witnessed cardiac arrest

In critical care areas (e.g. emergency department, coronary care, intensive care, cardiac catheter laboratory, operating theatres) when a monitored and witnessed cardiac arrest occurs in a well oxygenated patient, and a defibrillator is rapidly available (< 20 sec), or may already be attached to the patient:

Confirm cardiac arrest and shout for help.

If the initial rhythm is VF/pVT, administer up to three quick successive (stacked) shocks (without commencing chest compressions).

Rapidly check for a rhythm change and, if appropriate check for a pulse and other signs of ROSC after each defibrillation attempt.

If the third shock is unsuccessful or the rhythm is asystole or PEA start chest compressions and continue CPR following the ALS algorithm while considering any special circumstances of the arrest (see ANZCOR Special Circumstances Guideline 11.10)

A precordial thump may be used immediately whilst awaiting the arrival of a defibrillator in a monitored pVT arrest, it is not recommended for ventricular fibrillation as it is ineffective.

8 Background evidence for health care professionals

The purpose of cardiopulmonary resuscitation is to provide sufficient vital organ blood flow (e.g. to brain, heart) to preserve life until definitive procedures can be performed (e.g. defibrillation, correction of underlying cause). Compared with BLS providers, ALS providers are more likely to have performed and practised CPR. Despite this, observational studies of the actual performance of CPR by heath care professionals have revealed inadequate depth of compressions,[15] excessive ventilation rates,[16] and excessive interruptions to external cardiac compressions.[17] The general principles of cardiopulmonary resuscitation remain the same for ALS providers as for BLS providers: provide good quality compressions, minimise interruptions to compressions, fill the lungs with oxygen, and provide ventilation but avoid excessive ventilation.

Health care professionals should be trained to provide CPR with 30 chest compressions and 2 ventilations for adult patients (15:2 in children) in cardiac arrest. Performing chest compressions alone is reasonable for trained individuals if they are unable to deliver ventilations to cardiac arrest patients.[2]

The risk of disease transmission is very low and initiating rescue breathing without a barrier device is reasonable. If available, rescuers may consider using a barrier device.[2] Rescuers should take appropriate safety precautions, especially if a patient is known to have a serious infection e.g. human immunodeficiency virus (HIV), tuberculosis, hepatitis B virus.[2]

Responders should put on personal protective equipment (PPE) (e.g. gloves) as soon as possible when performing CPR. CPR should not be delayed or withheld if PPE is not available unless there is a clear risk to the rescuer.[2] There are few reports of psychological harm to rescuers after being involved in a resuscitation attempt. There is insufficient evidence to support or refute any recommendation on minimizing the incidence of psychological harm to rescuers.[2]

8.1 When to Commence CPR

The sequence of events for BLS is the same for ALS providers (see ANZCOR Guideline 8). If the adult patient is not responsive, the airway should be cleared and breathing assessed, and if the patient is not breathing normally, then CPR should be commenced with 30 chest compressions followed by 2 ventilations. In children, the same assessment sequence should be followed but advanced life support providers deliver ventilation prior to chest compressions.

Recommendation

It is reasonable that lay rescuers and health care professionals commence CPR in patients who are unresponsive and not breathing normally.[10] A pulse check (even in the hands of healthcare professionals) has limitations[18] but if an ALS provider is trained in that technique they can also check for a central pulse (e.g. carotid) for up to 10 seconds during the period of assessment for signs of life [Class A; LOE Expert Consensus Opinion].

Palpation of the pulse as the sole indicator of the presence or absence of cardiac arrest is unreliable. Agonal gasps are common during cardiac arrest and should not be considered normal breathing.

The general public and healthcare workers should be taught how to recognize agonal gasps as a sign of cardiac arrest.[10]

8.2 Where to Compress

There is insufficient evidence to support any particular technique for identifying a compression point or a specific hand position for chest compressions during CPR in adults. Manikin studies in health care professionals showed improved quality of chest compressions when the dominant hand was in contact with the sternum.[19] The desired compression point for CPR in adults is over the lower half of the sternum. Compressions provided higher than this becomes less effective, and compressions lower than this are less effective and have an increased risk of damage to intra-abdominal organs. Two techniques were previously taught to find the correct compression point (e.g. calliper method and alternative method) however there were shorter pauses between ventilations and compressions if the hands were simply positioned 'in the centre of the chest'.[19]

Recommendation

For chest compressions, it is recommended that rescuers place their hands on the lower half of the sternum. It is recommended to teach this location in a simplified way, such as, 'place the heel of your hand in the centre of the chest with the other hand on top.' This instruction should be accompanied by a demonstration of placing the hands on the lower half of the sternum. Use of the inter-nipple line as a landmark for hand placement is not reliable.[10] [Class A; LOE Expert Consensus Opinion]

8.3 Depth of Compression

Despite ALS training and regular practice, in both out-of-hospital and in-hospital observational studies, insufficient depth of compression (when compared with currently recommended depths) was commonly observed during CPR. Three adult human studies show that the measured compression depth during adult human resuscitation is often less than 4 cm. No human studies directly compared the effectiveness of currently recommended compression depth of more than 5 cm in adults with alternative compression depths.[10]

The ideal depth of compression for human cardiac arrest management remains unknown. One adult human case series two adult human studies with retrospective control groups and one additional study suggest that compressions of 5 cm or more may improve the success of defibrillation and ROSC. These findings are supported by three swine studies showing improved survival with deeper compression depths, and one adult human study showing that improved force on the chest produced a linear increase in systolic blood pressure. However, one swine study reported no improvement of myocardial blood flow with increased compression depth from 4 cm to 5 cm although coronary perfusion pressure (CPP) improved from 7 to 14 mm Hg.[10]

There is a high degree of variability in the size and shape of adult chests. In one CT study of 100 patients, compression depths of 4-5 cm equated to approximately 16-21% of the depth (AP diameter) of an adult chest.[20]

Recommendation

When performing chest compressions it is reasonable to compress the sternum at least one third of the depth of the chest [Class B; LOE Expert Consensus Opinion] or at least 5cm for all adult cardiac arrest patients [COSTR 2015 strong recommendation, low quality evidence].[21] ARC places greater importance on adequate compression depth. Although there is some evidence suggesting detriment with compression depths greater than 6cm, the clinical reality of being able to tell the difference between 5 or 6 cm and adjust compressions accordingly is questionable. Inadequate compression depth is definitely associated with poor outcomes. ARC has elected not to put an upper limit on compression depth as the risk of too shallow compressions outweighs the risk of compressions that are too deep. [COSTR 2015 Values and Preferences Statement].[21]

8.4 Rate of Compression

The optimal rate of cardiac compression during cardiac arrest is not known. Some studies in animal models of cardiac arrest showed that high-frequency CPR (120-150 compressions/min) improved haemodynamics without increasing trauma when compared with 60 compressions/min, whereas others showed no such benefit.

Some studies in animals showed more effect from other variables, such as duty cycle (see below). In humans, high-frequency CPR (120 compressions/min) improved haemodynamics over 60 compressions/min.[22] However, in observational studies of mechanical CPR in humans high-frequency CPR (up to 140 compressions/min) showed no improvement in haemodynamics when compared with 60 compressions/min.[19]

Recommendation

It is reasonable for lay rescuers and healthcare providers to perform chest compressions at a rate of 100-120 compressions per minute [COSTR 2015 strong recommendation, very-low-quality evidence].[21]

ARC acknowledges that compression rates will vary between and within providers. Nevertheless, survival rates are optimised at compressions rates of 100-120 compressions per minute. There is some evidence that compressions rates less than 100 or greater than 140 compressions per minute are associated with lower rates of survival.[21,23,24] [COSTR 2015 Values and Preferences Statement] [21]

Pauses should be minimised to maximise the number of compressions delivered per minute.[10]

8.5 Compression: Relaxation Ratio (Duty Cycle)

The term duty cycle refers to the time spent compressing the chest as a proportion of the period between the start of one compression and the start of the next.

Coronary blood flow is determined partly by the duty cycle (reduced coronary perfusion with a duty cycle >50%) and partly by how fully the chest is relaxed at the end of each compression. One animal study that compared duty cycles of 20% with 50% during cardiac arrest chest compressions showed no statistical difference in neurological outcome at 24 h. A mathematical model of Thumper CPR showed significant improvements in pulmonary, coronary, and carotid flow with a 50% duty cycle when compared with duty cycles of > 50%.

At duty cycles of between 20 and 50%, coronary and cerebral perfusion in animal models increased with chest compression rates of up to 130-150 compressions/min.

In a manikin study, duty cycle was independent of the compression rate when rescuers increased progressively from 40 to 100 compressions/min. A duty cycle of 50% is mechanically easier to achieve with practice than duty cycles of <50%.[19]

Recommendation

It is reasonable to use a duty cycle of 50% (i.e. equal time spent in compression and release). [Class A; LOE Other: Manikin & Animal studies]

8.6 Decompression

There are no human studies specifically evaluating ROSC or survival to hospital discharge with or without complete (chest wall recoil) during CPR. One out-of-hospital case series documented a 46% incidence of incomplete chest recoil by professional rescuers using the CPR technique recommended in 2000, and two in-hospital paediatric case series demonstrated a 23% incidence of incomplete recoil that was more common just following switching providers of chest compressions. Another study electronically recorded chest recoil during in-hospital paediatric cardiac arrests and found that leaning on the chest occurred in half of chest compressions.

Animal studies demonstrate significant reductions in mean arterial pressure, coronary perfusion pressure, cardiac output, and myocardial blood flow with only small amounts of incomplete chest recoil. Chest recoil can be increased significantly with simple techniques; for example, lifting the heel of the hand slightly but completely off the chest during CPR improved chest recoil in a manikin model. However, these alternative techniques may also reduce compression depth.[10]

Recommendation

While allowing complete recoil of the chest after each compression may improve circulation, there is insufficient evidence to determine the optimal method to achieve the goal without compromising other aspects of chest compression technique.[10]

8.7 Provision of a Firm Surface for CPR

One case series and four manikin studies demonstrated that chest compressions performed on a bed are often too shallow.[10] No studies have examined the risks or benefits of moving the patient from a bed to the floor to perform CPR.[10] No studies in humans have evaluated the risks or benefits of placing a backboard beneath a patient during CPR. Manikin studies suggested that placing a backboard may improve compression depth by a few millimetres.[10] One manikin study showed that deflating a special mattress improved compression efficiency, but another manikin study failed to demonstrate any benefit from deflating an air-filled mattress.[10]

Recommendation

CPR should be performed on a firm surface when possible. Air filled mattresses should be routinely deflated during CPR. There is insufficient evidence for or against the use of backboards during CPR. If a backboard is used, rescuers should minimise delay in initiation of chest compressions, minimise interruption in chest compressions, and take care to avoid dislodging of catheters and tubes during backboard placement.[10] [Class A; LOE Manikin study] Rescuers who use devices that provide feedback on CPR quality should be aware of the potential overestimation of compression depth when the patient is on a soft surface.

8.8 Minimise Interruptions to CPR

Interruptions in external cardiac compressions result in a fall in coronary perfusion pressure, [25] and an associated decrease in the likelihood of successful defibrillation.[26, 27]

Recommendation

Rescuers should minimise interruptions of chest compressions during the entire resuscitation attempt.[10]

CPR should be continued without interruptions unless the patient responds, starts breathing normally, or it is necessary to stop to perform specific tasks (e.g. tracheal intubation, rhythm analysis or defibrillation). It is recommended that attempts at intubation should ideally not interrupt cardiac compressions at all. For health care professionals, it is reasonable to check a pulse if an organized rhythm is visible on the monitor at the next rhythm check.[10] [Class A; LOE Expert Consensus Opinion]

The planned pauses in cardiac compressions for rhythm analysis (and/or pulse check) should not take more than 10 seconds, and compressions should be continued up until the time of defibrillation. Ensure that shocks are delivered only when all rescuers are well clear of the patient.

8.9 Compression: Ventilation Ratio

There is insufficient evidence that any specific compression: ventilation ratio is associated with improved outcome in patients with cardiac arrest.[10] The minute ventilation requirements during cardiac arrest are not known. A normal respiratory rate of 10-12 breaths per minute may be detrimental in the presence of low cardiac output (including during cardiac arrest). In an animal study, 12 breaths per minute appeared excessive.[28] Emphasis should be placed on trying to oxygenate the aortic blood rather than removing carbon dioxide during low flow states. Oxygen should be administered as soon as possible.

Recommendation

Health care professionals should provide chest compressions with ventilations for cardiac arrest patients. There is insufficient evidence to support or refute the provision of chest compressions plus airway opening and oxygen insufflation by professional rescuers during the first few minutes of resuscitation from cardiac arrest.[10] In adult cardiac arrest patients, to maximise the number of compressions given, minimise interruptions of chest compressions, and simplify instruction for teaching and skills retention, a single compression: ventilation ratio of **30:2** is recommended **before the airway is secured** irrespective of the number of rescuers. [Class A; LOE Expert Consensus Opinion]

In paediatric advanced life support rescue by healthcare rescuers (see ANZCOR Guideline 12.2), the ratio should be 2 breaths then 15 compressions. Rescuers trained in paediatric advanced life support may use the BLS approach (30:2) in circumstances where this is more achievable. Examples might include rescuers working with others trained in the 30:2 approach, being a solo rescuer, or adverse physical environments.

After an advanced airway (e.g. tracheal tube, supraglottic airway) is in place, ventilate the patient's lungs with 100% oxygen to make the chest rise. During CPR for a patient with an advanced airway in place, it is reasonable to ventilate the lungs at a rate of 6 to 10 ventilations per minute, without pausing during chest compressions to deliver ventilations. [CoSTR 2015, weak recommendation, very low quality evidence].[3] Compressions need not be paused, but ventilations will need to be timed to avoid simultaneous ventilation and compression. Simultaneous ventilation and compression may adversely affect coronary perfusion,[22] and has been associated with decreased survival.[29] As previously recommended, one starting point to provide consistent ventilation and an adequate minute volume while minimising interruptions to CPR, and minimising the likelihood of excessive ventilation, is to provide one breath after each 15 compressions (delivering the breath during the relaxation phase of compression, without a significant pause).[25] [Class B; LOE Expert Consensus Opinion]

Adequacy of chest rise and fall must be assessed for each breath, but it is easier to ensure that a single delivered breath is adequate once the airway has been secured.

For mouth-to-mouth ventilation for adult patients using exhaled air or bag-mask ventilation with room air or oxygen, it is reasonable to administer each breath within a 1 second inspiratory time to achieve chest rise. It is reasonable to use the same initial tidal volume and rate in patients regardless of the cause of the cardiac arrest.[10] [Class B; LOE Expert Consensus Opinion].

8.10 Fatigue

The compression rate and depth is variable among rescuers and compressions may be worse in the first 5 minutes of the arrest.[15] One manikin study of rescuer CPR showed that compressions became shallow within one minute, but providers became aware of fatigue only after 5 min.[19]

Recommendation

When feasible, rescuers should frequently alternate the role of chest compressions (e.g. every 2 minutes), regardless of whether they feel fatigued, to ensure that fatigue does not interfere with delivery of adequate chest compressions. [Class A; LOE Manikin study] Rescuer fatigue may be demonstrated by deterioration in chest compression quality, in particular, depth of compressions. The change of rescuers performing chest compressions should be done with minimum interruption to the compressions.[10]

8.11 Performing CPR While Preparing to Administer a Shock

When using a defibrillator in manual mode, it is safe to charge the defibrillator while chest compressions continue in preparation for rhythm analysis and possible defibrillation.[30] This approach is not applicable when using a defibrillator in AED mode.

There is insufficient evidence to recommend that continuing manual chest compressions during shock delivery for defibrillation is safe.

8.12 Recommence CPR Immediately After a Shock

The recommendation to immediately start/recommence CPR after a shock is based on the observation that in the first minute or so after defibrillation the chance of developing a rhythm associated with an output is extremely small.[27, 31] Starting CPR immediately after defibrillation, irrespective of the electrical success (or otherwise) of the attempt at defibrillation, restores blood flow to the brain and heart and creates a milieu more conducive to return of spontaneous circulation. A period of high quality CPR (e.g. for 1-3 minutes) appears to be able to increase the likelihood of success of the next attempt at defibrillation.[7, 26]

Five animal studies and one human study confirmed that more interruption of chest compressions during CPR reduced ROSC and survival.[10] In two case series, a palpable pulse was rarely present immediately after defibrillation, suggesting that a pulse check after a shock is not useful and delays the resumption of chest compressions.[10]

In two adult out-of-hospital witnessed VF studies with historical controls and three animal studies immediate resumption of chest compressions after defibrillation was associated with better survival rates and/or survival with favourable neurological outcome compared with immediate rhythm analysis and delayed resumption of chest compression.[10] However, in one randomised study, immediate resumption of chest compressions after defibrillation was associated with earlier VF recurrence when compared to a pulse check prior to resumption of CPR; there was no difference in cumulative incidence of VF 60 s after the shock.[10]

Recommendation

CPR should be recommenced immediately after attempting defibrillation, irrespective of the apparent electrical success (or otherwise) of the attempt [Class A; LOE Expert Consensus Opinion].

After about 2 minutes of CPR, or earlier if responsiveness or normal breathing become apparent, the rhythm should be checked. If a rhythm compatible with spontaneous circulation is observed then the pulse should also be checked [Class A; LOE Expert Consensus Opinion].

8.13 Monitoring Adequacy of CPR

The simplest and most important component of monitoring is the clinical assessment of the adequacy of CPR: observation of the appropriateness of the technique of compressions (positioning, rate and depth) and ventilation (rate, and depth). Such monitoring will allow feedback regarding technique and possible fatigue.

A number of devices may also be available to monitor the adequacy of CPR.[32] Eleven studies showed that physiologic monitoring values (end tidal CO_2, coronary perfusion pressure, venous oxygen saturation) increased when return of spontaneous circulation was achieved and may be an indication of ROSC before it can be seen in vital signs.[13]

8.14 End-tidal carbon dioxide monitoring to guide therapy during cardiac arrest

No studies have addressed this question directly. In experimental models, the end-tidal carbon dioxide concentration during ongoing CPR correlated with cardiac output, coronary perfusion pressure, and successful resuscitation from cardiac arrest. Thirteen studies indicated that higher maximal end-tidal CO_2 levels can predict ROSC. Seven studies demonstrate that end-tidal CO_2 values <10 mmHg obtained after intubation and during CPR efforts are associated with a low probability of survival from cardiac arrest. However, two studies documented patients who did not meet the $ETCO_2$ range but who survived. Multiple studies by one group showed that when $ETCO_2$ exceeded 10 mm Hg, all patients achieved ROSC. In one of these studies all the survivors had an initial $ETCO_2$ higher than 10mmHg. Similarly, two studies showed that if the $ETCO_2$ did not exceed 10 mmHg, survival was zero.[13] Two prospective human studies demonstrated a significant increase in end-tidal CO_2 when ROSC occurs.[13]

Recommendation

Quantitative measurement of end tidal CO_2 is a safe and effective non-invasive indicator of cardiac output during CPR and may be an early indicator of return of spontaneous circulation in intubated patients. Continuous capnography or capnometry monitoring, if available, may be beneficial by providing feedback on the effectiveness of chest compressions.[13]

ARC suggests that an $ETCO_2$ of 10 mm Hg or greater measured after tracheal intubation or after 20 minutes of resuscitation, may be a predictor of ROSC (CoSTR 2015, weak recommendation, low-quality evidence).[3]

ARC suggests that an $ETCO_2$ of 10 mm Hg or greater measured after tracheal intubation, or an ETCO2 of 20 mm Hg or greater measured after 20 min of resuscitation may be a predictor of survival to discharge (CoSTR 2015, weak recommendation, moderate-quality evidence).[3]

Although low values of end tidal CO_2 are associated with a low probability of survival, there are insufficient data to support or refute a specific cut off of end tidal CO_2 at different time intervals as a prognostic indicator of outcome during adult cardiac arrest. ARC recommends against using $ETCO_2$ cut-off values *alone* as a mortality predictor, or for the decision to stop a resuscitation attempt (CoSTR 2015, strong recommendation, low-quality evidence).[3]

During a cardiac arrest, the $ETCO_2$ value should not be used as a guide for ventilation, and rescuers should be wary about using it to guide ventilation in the immediate post resuscitation phase.

8.15 Arterial blood gas monitoring during cardiac arrest

There was evidence from one case series and 11 other related studies that arterial blood gas values are not accurate indicators of the magnitude of tissue acidosis during cardiac arrest and CPR in both the in-hospital and out-of-hospital settings. The same studies indicate that both arterial and mixed venous blood gases are required to establish the magnitude of the tissue acidosis.

Arterial blood gas analysis can disclose the degree of hypoxaemia and highlight the extent of metabolic acidosis. Arterial CO_2 is an indicator of adequacy of ventilation during CPR. If ventilation is constant an increase in $PaCO_2$ is a potential marker of improved perfusion during CPR.[13]

Improvements in blood gases may be due to better ventilation or increased cardiac output and are thus only an approximate indicator of the adequacy of ventilation during CPR.

Recommendation

Arterial blood gas monitoring may be considered during cardiac arrest as it enables estimation of the degree of hypoxaemia and the adequacy of ventilation during CPR but is not a reliable indicator of the extent of tissue acidosis. [Class A; LOE II-IV, Other]

Low levels of $PaCO_2$ may indicate a need to reduce the respiratory rate. High levels of $PaCO_2$ may need to be tolerated during resuscitation attempts, as the potential benefits of increasing the ventilation rate during CPR must be balanced against the potential detrimental effects (increased intra-thoracic pressure, and decreased coronary perfusion pressure). [16] Blood sampling also allows estimation of electrolyte concentrations (including potassium, calcium and magnesium). Blood sampling should not interrupt chest compressions.

8.16 Coronary perfusion pressure to guide resuscitation

Coronary perfusion pressure (CPP; aortic relaxation [diastolic] pressure minus the right atrial relaxation pressure) during CPR in humans correlated with both myocardial blood flow and ROSC: a value ≥15mmHg is predictive of ROSC. Increased CPP correlates with improved 24-h survival in animal studies and is associated with improved myocardial blood flow and ROSC in animal studies involving adrenaline, vasopressin, and angiotensin II.[33]

Recommendation

Coronary perfusion pressure can be used as a guide to therapy during cardiac arrest [Class B; LOE III-2].

In an intensive care facility, the availability of direct arterial and central venous pressure monitoring makes calculation of CPP potentially useful. Outside the intensive care facility the technical difficulties of invasive monitoring of arterial and central venous pressure make it difficult to calculate CPP routinely during cardiac arrest.

8.17 Real-Time Feedback Devices

Eleven studies investigated the effect of giving real-time CPR performance feedback to rescuers during actual cardiac arrest events in both in-hospital and out-of-hospital settings. Two studies with concurrent controls in adults and one study with concurrent controls in children showed improved end-tidal CO_2 measurements and consistent chest compression rates when feedback was provided from audio prompts (metronomes or sirens).[10]

In four studies with retrospective controls, and two case series, real-time feedback from force transducers and accelerometer devices was useful in improving CPR quality metrics, including compression depth, rate, and complete chest recoil.[10]

Two manikin studies demonstrated the potential for overestimating compression depth when using an accelerometer chest compression feedback device if compressions are performed (with or without a backboard) on a soft surface. No studies to date have demonstrated a significant improvement in long-term survival related to the use of CPR feedback/prompt devices during actual cardiac arrest events.[10]

Recommendation

Real-time chest compression-sensing and feedback/prompt technology (i.e. visual and auditory prompting devices) may be useful adjuncts during resuscitation efforts. However, rescuers should be aware of the potential overestimation of compression depth when the patient is on a soft surface.[10]

CPR prompt /feedback devices may be considered for clinical use as part of an overall strategy to improve the quality of CPR. Instructors and rescuers should be made aware that a compressible support surface (e.g. mattress) may cause a feedback device to overestimate depth of compression.[2]

There is no high level evidence that the use of CPR feedback devices during real time CPR improves survival or return of spontaneous circulation.[21] [COSTR 2015 weak recommendation, very low quality evidence] CPR prompt / feedback devices may be considered for clinical use to provide data as part of an overall strategy to improve quality of CPR at a systems level. [21, 2] [COSTR 2015 weak recommendation, very low quality evidence]

ARC places a higher value on resource allocation and cost effectiveness than widespread implementation of a technology with uncertain effectiveness during real time CPR. We acknowledge that data provided by CPR feedback devices may benefit other patients as part of a broader quality improvement system.[21] [COSTR 2015 Values and Preferences Statement]

8.18 Audit, Feedback and Quality Improvement

In a number of case series, the CPR compression rate and depth provided by lay responders, physician trainees and emergency services personnel were insufficient when compared with the methods recommended at that time.[19] Ventilation rates and durations higher or longer than recommended when CPR is performed impaired haemodynamics and reduced survival rates in animals.[16] It is likely that poor performance of CPR in humans also impairs haemodynamics and possibly survival rates. Allocating personnel or equipment to specifically monitor the rate and depth of compressions and ventilation may improve performance.

Recommendation

It is reasonable for instructors, trainees, providers, and emergency services to monitor and improve the process of CPR to improve the CPR quality by ensuring adherence to recommended compression and ventilation rates and depths. [Class B; LOE Expert Consensus Opinion] It is reasonable to recommend the use of briefings and debriefings during both learning and actual clinical activities.[2] [Class B; LOE Expert Consensus Opinion]

It is reasonable to use cognitive aids (e.g. checklists) during resuscitation provided they do not delay the start of resuscitation efforts. Aids should be validated using simulation or patient trials, both before and after implementation to guide rapid cycle improvement.[2] [Class B; LOE Expert Consensus Opinion]

8.19 Harm to Patients during CPR

Post-mortem studies have identified a significant number of thoracic injuries after CPR.[35] There are no data to suggest that the performance of CPR by bystanders leads to more complications than CPR performed by professional rescuers. One study documented no difference in the incidence of injuries on chest radiograph for arrest patients with and without bystander CPR. One study documented a higher rate of complications among inpatient arrest patients treated by less-experienced (non-ICU) rescuers. Two studies reported that serious complications among non-arrest patients receiving dispatch-assisted bystander CPR occurred infrequently. Of 247 non-arrest patients with complete follow up who received chest compressions from a bystander, 12% experienced discomfort; only 5 (2%) suffered a fracture;

and no patients suffered visceral organ injury.[35]

Recommendation

In individuals with presumed cardiac arrest, CPR rarely leads to serious harm in patients who are eventually found not to be cardiac arrest; and therefore CPR should be assertively encouraged.[10] [Class A; LOE III-2 to IV] Rib fractures and other injuries are common but acceptable consequences of CPR given the alternative of death.[10] [Class A; LOE IV, extrapolated evidence] CPR should be initiated for presumed cardiac arrest without concerns of harm to patients not in cardiac arrest.[21] [COSTR 2015, strong recommendation, very-low-quality evidence].

In making this recommendation, ARC places a higher value on the survival benefit of CPR initiated by laypersons and others for patients in cardiac arrest against the low risk of injury in patients not in cardiac arrest. [21]

8.20 Ventilation rates after return of spontaneous circulation

The requirements for alveolar (minute) ventilation after return of spontaneous circulation depend on the specific circumstances. As with no cardiac output, in situations of limited cardiac output, the requirements for ventilation will also be reduced. Higher ventilatory rates, with increases in intrathoracic pressure, can still decrease venous return and cardiac output.

Recommendation

After return of spontaneous circulation it is reasonable to use a ventilation rate of approximately 12/min until blood gas confirmation of $PaCO_2$ is available [Class B; LOE Exert Consensus Opinion].

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